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OUTGASSING MEASUREMENT OF THE ALUMINUM ALLOY
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16. Abstract A large vacuum chamber (580 mm diameter) was fabricated from aluminum alloy surface-treated by a special process normally used on small chambers. The chamber was tested unbaked and baked at various temperatures, pressures, and holding periods. The chamber was filled with N ₂ gas, and outgassing rate was measured after one hour. Then ultimate pressure was measured. Outgassing rates for baked and unbaked groups were compared. It is concluded that the same surface treatment technique can be used on both large and small chambers produced by the same special extrusion process.			
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M. Miyamoto, T. Itoh, S. Komaki, K. Narushima, H. Ishimaru

1. Foreward

The UHV chamber system, made from aluminum alloy, has /87* recently attracted special attention. The pace of its development and application has appeared to accelerate.

To date, the extremely low outgassing rate of aluminum alloy vacuum chambers has been obtained through the use of a special extrusion process [1]. Because of this special extrusion process, the chamber currently available is limited to a tube with an outside diameter of under 200 mm. A few reports have been published on the outgassing characteristics of aluminum alloy chambers made of A6063, Al060, etc., using this special extrusion process [1-3]. In order to obtain the same extreme low outgassing rate, the EX process (special surface treatment technique) was selected for use in applying aluminum alloy to the MBE system. Basic research was conducted on the aluminum alloy MBE system, using the EX process to make a large aluminum alloy chamber for trials; its outgassing characteristics and ultimate pressure measurements are given.

2. Fabrication of an aluminum alloy vacuum chamber

The main body was of Al050 plate material, rolled into a cylindrical shape and welded at the seam using the TIG fusion process. The ends of the cylinder were roughened both internally and externally before the fusion process. A large

*Numbers in the margin indicate pagination of the foreign text.

flange with a diameter of 700 mm was made of A2219-T87; the part requiring an airtight seal was finished to mirror-smoothness [4]. The airtight seal face was processed with about 2 microns of Cr-N coating instead of ion plating. ICF203W, ICF152W, and ICF70W (W indicates the type of welding used to connect pipes) were used to produce the aluminum alloy conflated flange [5]. Welding was accomplished using the AC-TIG fusion process with plentiful shielded argon gas. The small flange was joined to the cylindrical inner surface of the large flange, and these were joined to the large vacuum chamber by Ar+O₂ gas cutting (EX process). A gasket was formed on the large flange with aluminum-covered helico-flux. A gasket was formed on the aluminum-alloy-coated flange with aluminum Al050-H18. This aluminum alloy test chamber had a main cylindrical body with a diameter of 580 mm, length of 1,000 mm, volume of 240 liters, and surface area of 2.5×10^4 cm².

3. Measurement of outgassing rate

An L-shaped tube and 6-mm diameter orifice were attached to the aluminum alloy chamber B-A gauges. A rotary pump, called a turbo-pump, with a pumping rate of 270 l/sec was used. With B-A gauges (ULVAC-G1-N3) upstream and downstream of the orifice, a so-called "flow-through" method (exhaust flow measurement) was used to measure the outgassing rate (Fig. 1). /88

Let P_1 be the upstream pressure at the orifice, P_2 be the downstream pressure, C be the conductance of the orifice, and A be the inner surface area of the chamber. An equation can then be written as follows:

$$q = \frac{C}{A} (P_1 - P_2) \quad (1)$$

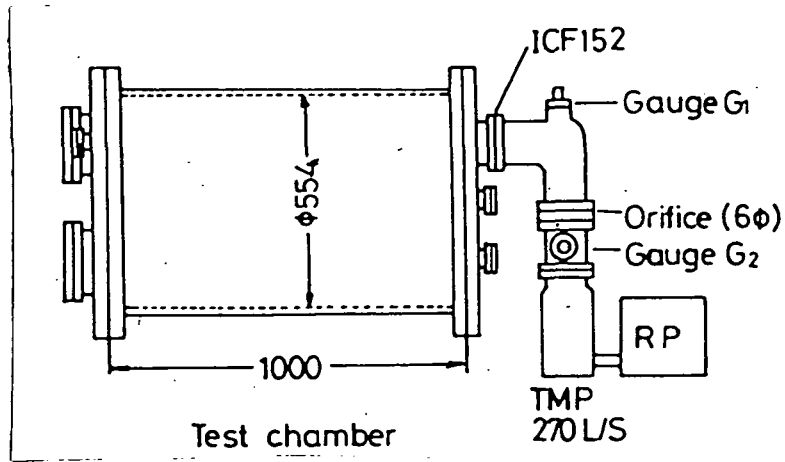


Fig. 1. Schematic diagram of the outgassing test system.

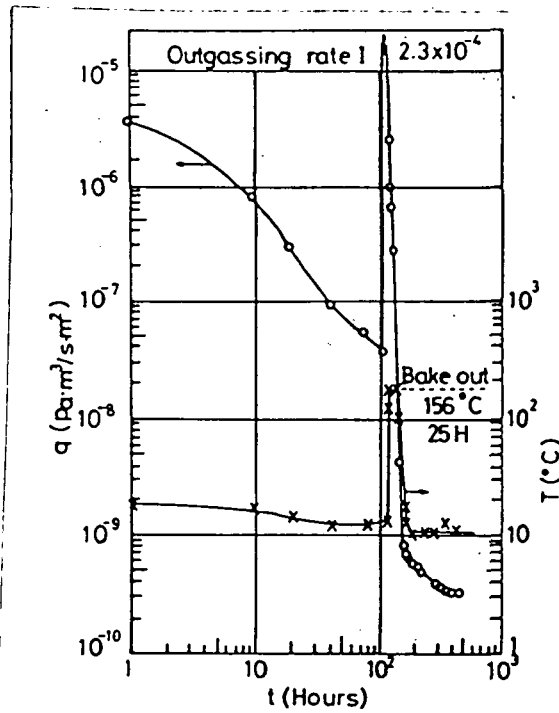


Fig. 2. Outgassing rates as a function of time from the initial state.

Fig. 2 shows the measurement of outgassing rate from the initial state. Baking temperature is 150°C and elapsed time is 25 hours.

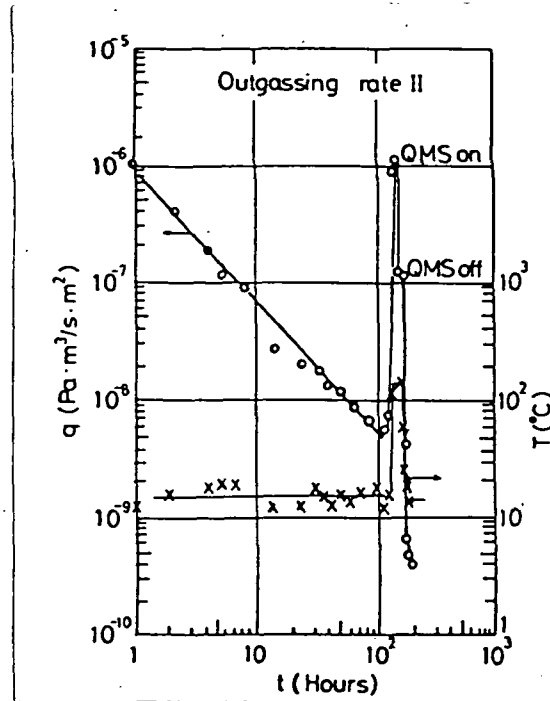


Fig. 3. Outgassing rates as a function of time II.

Next, N_2 gas was introduced at one atmospheric pressure into the vacuum chamber. One hour later, the gas was released and the outgassing rate was measured (Fig. 3). This time, baking temperature was 120°C and elapsed time was 24 hours. In comparing the above outgassing rate with Narushima's and Ishimaru's results [2], the measurements made on Al060 EX material before baking and on A6063 EX material after baking revealed the same indication [6]. In addition, air at atmospheric pressure was returned to the chamber and left there for about one month; then the gas was released and the outgassing rate measured (Fig. 4). This time, baking temperature was 110°C and elapsed time 24 hours. From the measured values in Fig. 2, Fig. 3, and Fig. 4, it is seen that, with the chamber left at atmospheric pressure for a length of time, the outgassing rate basically shows no change. These measurements, if compared with stainless steel material such as SUS304, etc., were 1 to 2 points lower than those of stainless steel.

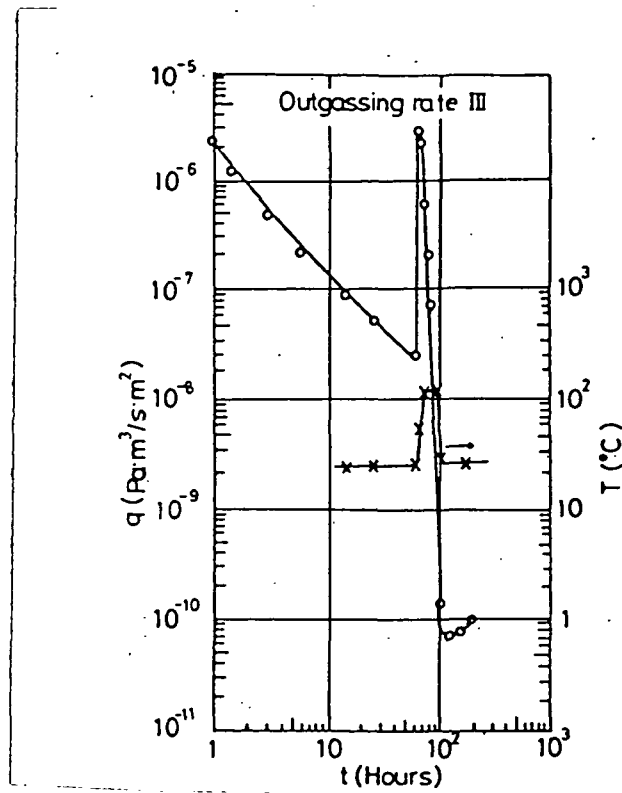


Fig. 4. Outgassing rates as a function of time III.

4. Measurement of ultimate pressure

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After a series of outgassing rate measurements was made on this test chamber, steps were taken to measure ultimate pressure with a system as shown in Fig. 5. The results are shown in Fig. 6. Before baking, an ultimate pressure in the range of 10^{-7} Pa was recorded. During baking, an aluminum alloy magnetized bearing turbo-pump was used for 150 hours. After baking at 120°C for 24 hours, using a 500 l/sec aluminum alloy ion pump (made by Fuzi Seiko), an ultimate pressure of 9×10^{-9} Pa was recorded.

An equation for ultimate pressure P_{∞} of the gas-releasing system can be written as follows:

$$P_{\infty} - P_0 = \frac{qA}{S} \quad (2)$$

where P_0 is the ultimate pressure of the pump and S is pumping speed.

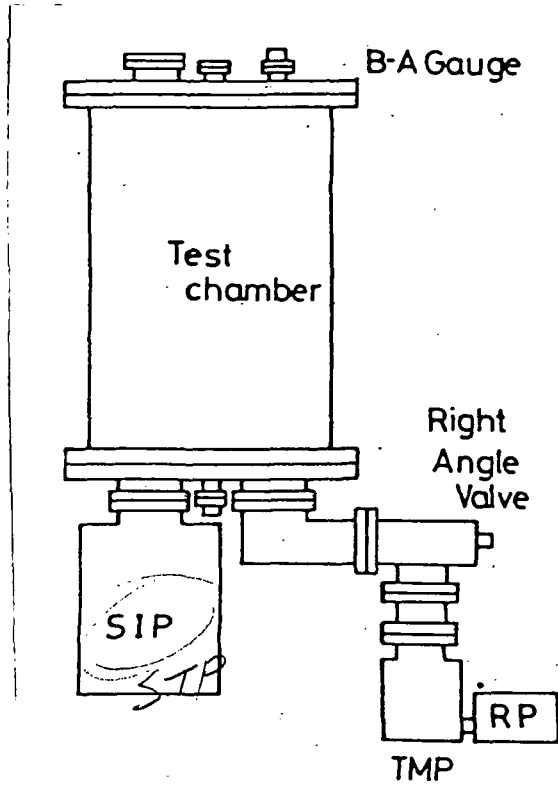


Fig. 5. Schematic diagram of the ultimate pressure measurement system.

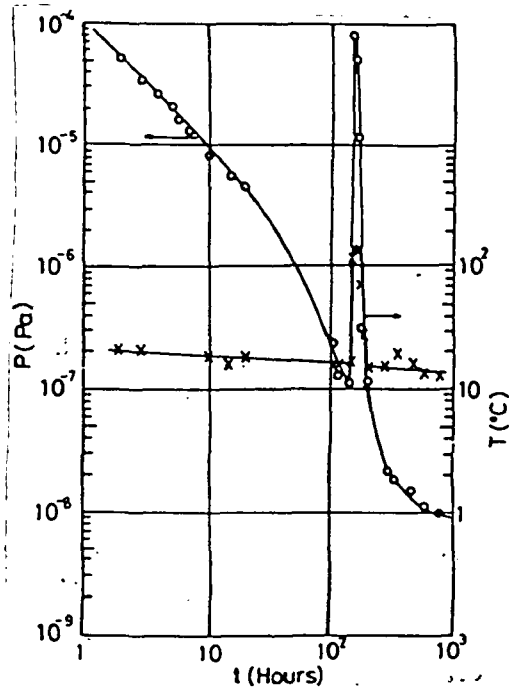


Fig. 6. Measurement of ultimate pressure.

Before baking, if the measured outgassing rate is 1.3×10^{-8} Pa x m³/S x m² and the pumping speed is 200 l/sec, then $P_{\infty} - P_0 = 1.7 \times 10^{-7}$ Pa. Under 10^{-8} Pa pressure, 80% of the residual gas can be predicted to be H₂, assuming that the pumping speed of an ion pump is 200 l/sec. If a measured outgassing rate of 1×10^{-10} Pa x m³/S x m² is used, then the equation $P_{\infty} - P_0 = 1.3 \times 10^{-9}$ Pa is obtained. These measured values seem to agree with each other.

5. Summary

From this test on a large chamber, the outgassing rates of 10^{-8} Pa x m³/S x m² for the unbaked group and 3×10^{-10} Pa x m³/S x m² for the baked group (at 120°C to 150°C with 24 hours elapsed time) were relatively easy to determine. It is possible that these values could be 1 to 2 points higher than those obtained using stainless steel material. Also, these values are similar to those obtained using the special extrusion process on A6063, etc. It is possible to use the same surface treatment technique on a large chamber as on a small one for the special extrusion process. Using an ion pump, an ultimate pressure of 9×10^{-9} was obtained; therefore, the future of the UHV system is very promising. /90

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